REMARKS

This Amendment is responsive to the Office Action mailed May 29, 2008. Reconsideration and allowance of the application based on these amendments and remarks is earnestly requested.

Status of the Claims

Claims 1-25 are pending. Claims 18-25 stand withdrawn. The Office Action reports examination of claims 1-17 and 26-28.

Claims 1-17 and 26-28 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over Zhu, U.S. Pat. No. 6,694,165 (hereinafter "Zhu") in view of Harvey et al., U.S. Publ. Appl. No. 2001/003162 (hereinafter "Harvey").

Claim Amendments

Withdrawn **claims 18-25** are canceled herein to expedite prosecution. Applicants reserve the right to prosecute these claims in a forthcoming divisional, continuation, or continuation-in-part application at Applicants' discretion.

New **claim 29** is drawn to the elected method, and recites k-space acquisition and reconstruction limitations taken from canceled apparatus claim 18.

New **claim 30** parallels claim 12 but depends from claim 29.

The claims present patentable subject matter and should be allowed

Claim 1 recites the k space samples in the outermost surrounding region being acquired last, the acquiring of k space samples in at least the outermost surrounding region using a row by row data acquisition ordering in which each row of k space samples acquired in the outermost surrounding region, together with selected already acquired k space data from the regions other than the outermost surrounding region, forms a completed data set for reconstructing an image plane; and reconstructing each completed data set into a reconstructed image plane without waiting for all k space samples in the outermost surrounding region to be acquired.

The Office Action cites Zhu as disclosing reconstruction "on the fly". Applicants agree that both the present application and Zhu enable concurrent acquisition and reconstruction such that something less than an entire final high resolution image can be displayed to the operator concurrently with acquisition.

However, it is respectfully submitted that Zhu's "on the fly" concurrent reconstruction is different in kind from the plane-by-plane reconstruction of the present application, and that moreover the acquisition sequence of Harvey is not readily compatible with the "on the fly" reconstruction approach of Zhu.

Zhu discloses acquiring and separately reconstructing "view groups" into "sub-images". The terms "view group" and "sub-image" are defined as follows:

> [A] view group refers to a set of views, and particularly, a set of views that are evenly spaced along an orthogonal k-space direction, e.g. with constant inter-view spacing (shown in FIG. 2, in which, for example, view group 1 is composed of views 1, 9, 17 and 25, and view group 2 is composed of views 2, 10, 18 and 26, the views being shown as solid lines). A sub-image refers to the result of the FFT of a given view group.
>
> Zhu col. 4 lines 16-24 (underscores added).

The sub-images previously generated at any point during the acquisition are combined in weighted fashion to generate a "component image":

> A component-image refers to the result of replicating and then weighting a sub-image (in accordance with Equations 2 and 3).
>
> Zhu col. 4 lines 24-26.

For completeness of terminology, an "intermediate image" as used in Zhu refers to either a component image or a sub-image. Zhu col. 4 lines 62-63.

The technique of Zhu is somewhat analogous to SENSE imaging in that an incomplete k-space data set is acquired (the view group) and is reconstructed into a sub-image, and the sub-images are combined in weighted fashion to ultimately generate a final image. However, whereas SENSE uses data from different simultaneously operating RF receive coils of different sensitivities to generate the sub-images, Zhu uses view groups acquired at different times to generate the sub-images. By displaying the weighted combination of sub-images as new sub-images are generated and added to the weighted combination, Zhu obtains "on-the-fly" reconstruction of the whole spatial range of the image.

The sub-images of Zhu are undersampled. In Zhu's example, view group 1 is composed of views 1, 9, 17 and 25, and view group 2 is composed of views 2, 10, 18 and 26, and so forth. Thus, for example, view group 1 is missing lines 2-8, 10-16, 18-24, and 26-32. A consequence of the undersampling of each view group is that the

intermediate images are aliased, as confirmed by Zhu at col. 6 lines 15-17 and readily visible for example in the sub-images (302) of Zhu Fig. 4.

The view of each view group are evenly spaced along an orthogonal k-space direction, e.g. with constant inter-view spacing, and span the whole of k-space (e.g., view group 1 includes lines 1, 9, 17, and 25 which span the k-space of range 1-32). As a result, each intermediate image is aliased due to undersampling but encompasses the whole spatial range of the image. Again, this feature is readily observed in the aliased images (302) of Zhu Fig. 4.

Claim 1 is different in kind. Claim 1 recites each row of k-space samples acquired in the outermost surrounding region, together with selected already acquired k space data from the regions other than the outermost surrounding region, forms a <u>completed data set for reconstructing an image plane</u>. Claim 1 further recites <u>reconstructing</u> each completed data set <u>into a reconstructed image plane</u> without waiting for all k space samples in the outermost surrounding region to be acquired.

Zhu's view group is not a completed data set for reconstructing an image plane. First, it is not a completed data set – rather, it is an undersampled data set. Second, it is not a data set for reconstructing an image plane – rather, although undersampled it spans the entire k-space so as to produce an image of the whole spatial range of the image, and not only of an image plane of the image.

(As an aside, the Office Action spends significant time discussing Zhu's teaching of filling in skipped views of a view group based on Hermitian symmetry, e.g. Zhu col. 7 lines 5-24. Applicants fail to see the relevance. There is no mention in the claims of filling skipped views by any mathematical technique whatsoever, much less by Hermitian symmetry. The present application recites acquiring <u>completed</u> data sets. While it is within the broad scope of the claims for the acquisition of a completed data set to include synthesizing a portion by Hermitian symmetry, this is not recited. Further, note that the view group of Zhu is still an incomplete, undersampled view group even when a portion of the view group is synthesized by Hermitian symmetry – Zhu is simply using the Hermitian symmetry "fill-in" trick to further enhance acquisition speed. Note particularly Zhu col. 7 lines 19-22, which states that the view groups are still reconstructed into sub-images to implement incremental "on-the-fly" reconstruction.)

The Office Action recognizes that Zhu does not disclose or fairly suggest dividing k-space into annular regions (Office Action at page 3), and proposes to remedy this deficiency by invoking the Harvey reference.

However, the proposed combination is non-functional. Zhu's "on-the-fly" reconstruction approach is predicated on the view groups being a set of views that are evenly spaced with constant inter-view spacing. These characteristics of the view groups ensure intermediate images (albeit possibly aliased) are of the whole spatial range of the image, which is the goal of Zhu.

If Zhu's view groups were replaced by the central region (40) and outer regions (50, 60) of Harvey, these view groups would not be reconstructable into meaningful images using the reconstruction-and-weighted combination of Zhu (e.g., using Zhu's Equations (2) and (3)). For example, reconstructing the central region (40) which is the first acquired "group" of Harvey, would not produce an aliased image of the whole spatial range of the image – indeed, it is not clear that this reconstruction would produce anything visually identifiable with spatial content of the subject.

The reason that claim 1 is operative with acquisition groups such as those of Harvey is that the concurrent acquisition/reconstruction of claim 1 is different in kind from that of Zhu. Claim 1 recites forming a completed data set for reconstructing an <u>image plane</u>, and reconstructing each completed data set <u>into a reconstructed image plane</u>. These operations are neither disclosed nor fairly suggested by Zhu, even when modified by Harvey.

The result is also entirely different. In Zhu, even the very first intermediate image reconstruction is of the whole spatial range of the image, albeit in an aliased and generally poor-quality form. <u>In contrast</u>, with the method of claim 1 the very first displayed image (as per claim 2, for example) is of a single reconstructed image plane, but that single reconstructed image plane is of full resolution and has no aliasing. In Zhu, as subsequent sub-images are generated and added to the weighted combination, the image remains of the same volume but becomes progressively less aliased and of generally "better" image quality. <u>In contrast</u>, with the method of claim 1 the image is built slice-by-slice as each successively completed data set for reconstructing an image plane is reconstructed into an additional reconstructed image plane that is added to the total image.

To establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. MPEP § 2143.03. Neither Zhu nor Harvey, nor their combination, disclose or fairly suggest forming a completed data set for reconstructing an image plane, or reconstructing each completed data set into a reconstructed image plane. Moreover, if proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. MPEP § 2143.01. As already discussed, replacing Zhu's view groups having their evenly spaced constituent views with the annular regions of Harvey would render Zhu inoperative for its intended purpose, and indeed the Zhu "on-the-fly" reconstruction technique would quite possibly be wholly inoperative.

In view of the foregoing, it is respectfully submitted that claims 1-17 and 26-28 present patentable subject matter. Accordingly, Applicants respectfully request allowance of claims 1-17 and 26-28.

Claim 29 recites the k-space samples in the outermost surrounding region being acquired last using a plane-by-plane acquisition ordering in which all k-space samples in the outermost surrounding region belonging to a current k space plane are acquired to complete the current k-space plane before samples in the outermost surrounding region belonging to other k-space planes are acquired; and reconstructing each completed current k-space plane into a reconstructed image plane without waiting for other k space planes to be completed.

Zhu does not acquire all k-space samples to complete a current k-space plane; rather, Zhu's view groups are undersampled. Zhu does not reconstruct a completed current k-space plane into a reconstructed image plane; rather, Zhu reconstructs its undersampled view groups into aliased intermediate images that encompass the whole spatial range of the image.

These deficiencies of Zhu cannot be remedied by Harvey. Although Harvey teaches k-space acquisition groups having geometries similar to those recited in claim 29, these geometries are not suitable substitutes for the view groups of Zhu, and any attempt to replace Zhu's view groups with the acquisition groups of Harvey would likely result in operative failure of Zhu's "on-the-fly" reconstruction method.

More fundamentally, Zhu's "on-the-fly" reconstruction method is materially different from the plane-by-plane reconstruction method of the present application. Although both Zhu and claim 29 enable concurrent acquisition and reconstruction, the operations recited in claim 29 (e.g., acquire all k-space samples to complete a current k-space plane; reconstructing each completed current k-space plane into a reconstructed image plane) have no analog in Zhu.

In view of the foregoing, it is respectfully submitted that claims 29 and 30 present patentable subject matter. Accordingly, Applicants respectfully request allowance of claims 29 and 30.

CONCLUSION

For the reasons set forth above, it is submitted that claims 1-17 and 26-30 are not anticipated by and distinguish patentably over the references of record. An early allowance of all claims is requested.

Respectfully submitted,

FAY SHARPE LLP

Robert M. Sieg

Thomas E. Kocovsky, Jr.
Reg. No. 28,383
Robert M. Sieg
Reg. No. 54,446
1100 Superior Avenue, 7th Floor
Cleveland, OH 44114-2579
(216) 861-5582